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Influence of temperature on compaction of ultrafiltration membranes

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Introduction

Membrane compaction is one of the reasons leading to decrease in membrane filtration capacity. It has been reported earlier that temperature increases compaction of polymeric membranes [1, 2]. However, real-time information on influence of temperature on membrane compaction has not been published. The real-time gathered compaction information enables improved understanding of temperature resistance and limits of the membranes. Thus, in this study the ultrasonic time-domain reflectometry (UTDR) was used to monitor compaction of different ultrafiltration membranes in real-time. The aim was to gather novel information on the influence on temperature on membrane compaction.

Methods

Four different commercial ultrafiltration membranes, the regenerated cellulose membranes UC030 (Microdyn-Nadir) and C30V (JSC STC Vladipor), the hydrophilic polyethersulfone membrane UH030 (Microdyn-Nadir) and the polyethersulfone membrane UP020 (Microdyn-Nadir), were used in the experiments. Before the exposure to pressure at different temperatures the membrane samples were washed with alkaline solution to remove preservatives and to wet the membranes. The experiments were repeated three times with each membrane type to confirm reproducibility of the results. A new piece of membrane was used in each experiment. The compaction experiments were done at 30, 50 and 70 °C at 1, 3, 5 and 7 bar pressure. During the compaction experiments, pure water fluxes were measured in order to see how the detected compaction affects in the filtration capacity. After the experiments, membranes were dried in room temperature and their structure was examined with scanning electron microscope (SEM). SEM examination was performed also with virgin membrane samples to enable evaluation of effect of membrane structure on its tendency to compact at different temperatures.

Results

The increase of temperature increased compaction tendency of the UC030 membrane significantly while it seemed that temperature increase had no effect on compaction of the other regenerated cellulose membrane C30V. Temperature increase affected also differently on compaction tendencies of the polyethersulphone membranes. The UH030 membrane was significantly less compacted at 50°C than the UP020. At 70°C the difference in compaction tendencies of the polyethersulphone membranes was smaller but the UH030 was still less compacted than the UP020. The SEM examination showed that the structure of the regenerated cellulose membranes differed greatly from each other. Some difference could also be seen between the structures of the polyethersulphone membranes. Thus, it can be suggested that the influence of temperature increase on membrane compaction tendency might be more related to membrane structure that to membrane material. At 1 bar pressure the temperature increase was seen as increased permeability with all the tested membranes, as was expected. At higher pressures, the effect of compaction of the UH030 membrane leads to similar permeabilities measured at 30°C and at 50°C. Same effect was observed with UP020 membrane. SEM studies confirmed the membrane compaction revealed in the UTDR measurements and by the pure water permeability measurements. The results from the compaction experiments done with the UC030 membrane are shown in Fig. 1 as an example.

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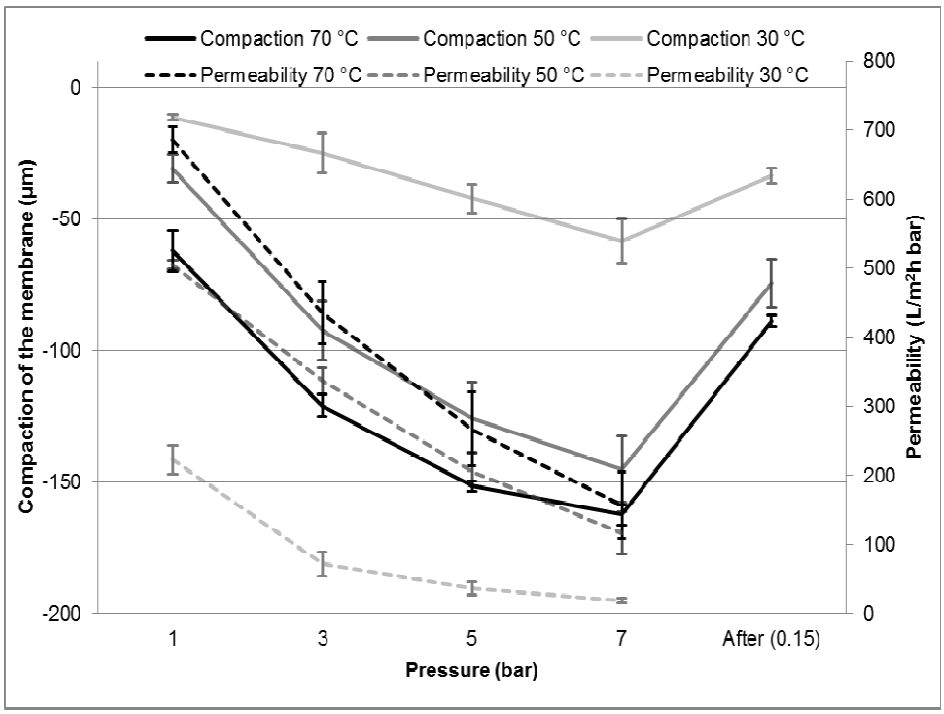

Figure 1. Permeability and compaction of UC030 membrane at 30, 50 and 70 °C.

Discussion

According to the results of this study, temperature might have a significant effect on membrane compaction tendency. However, the influence of temperature on compaction tendency is clearly related to membrane structure. Thus, there are significant differences in that how temperature increase might affect performance of the membranes made from same material type. These results reveal that real-time information on membrane compaction is relevant in optimizing the performance of a separation process via membrane choice.

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